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Tactical Decision-Making Under Uncertainty: Experiments I and II

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ADMINISTRATIVE INFORMATION

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EXECUTIVE SUMMARY

Tactical military information is, by definition, always uncertain to varying degrees. This is especially true regarding predictions of crucial future events such as enemy intent and troop movements. Nonetheless, traditional map-based information representations possess no technique for representing the degree of information uncertainty. In the first experiment, we developed textual and graphical representations of uncertain enemy intent and future troop movements on realistic battlefield maps that we compared against a baseline representation. Our assumption was that more easily remembered information leads to greater situation awareness which, in turn, leads to superior decision-making. Fleet Marine Force Marines with Combat Operations Center (COC) experience participated in the study. Maps employing graphical representations of enemy intent were superior to the baseline or text-based maps for recalling relative direction and relative distance of enemy future positions. In the second experiment, we examined the effects of battlefield information uncertainty on the nature of tactical decisions. Marines with substantial COC experience were unaffected by the degree of uncertainty concerning enemy strength and position, but less-experienced Marines were more likely to choose to wait before acting when uncertainty was high.

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INTRODUCTION

Good tactical decisions require good situation awareness, i.e., the perception and understanding of objects and their properties in a system user's environment and the projection of their status into the near future (adapted from Endsley, 1995). Good situation awareness includes an understanding of the extent to which critical information—regarding such things as the position, movement, and intention of enemy forces, the nature of the terrain, and even the position of friendly forces—is uncertain. The uncertainty of information, in turn, depends on many factors, including the source, reliability, and age of the information. Nonetheless, at any given time, most of what is known is only partially understood and should therefore be viewed as a mixture of the known and unknown, the certain and uncertain (Acredolo and O'Connor, 1991). The United States Marine Corps explicitly acknowledges the ubiquity and importance of uncertainty in its doctrinal publication, *Warfighting* (United States Marine Corps, 1997):

> "While we try to reduce these unknowns by gathering information, we must realize that we cannot eliminate them. The very nature of war makes absolute certainty impossible; all actions in war will be based on incomplete, inaccurate, or even contradictory information."

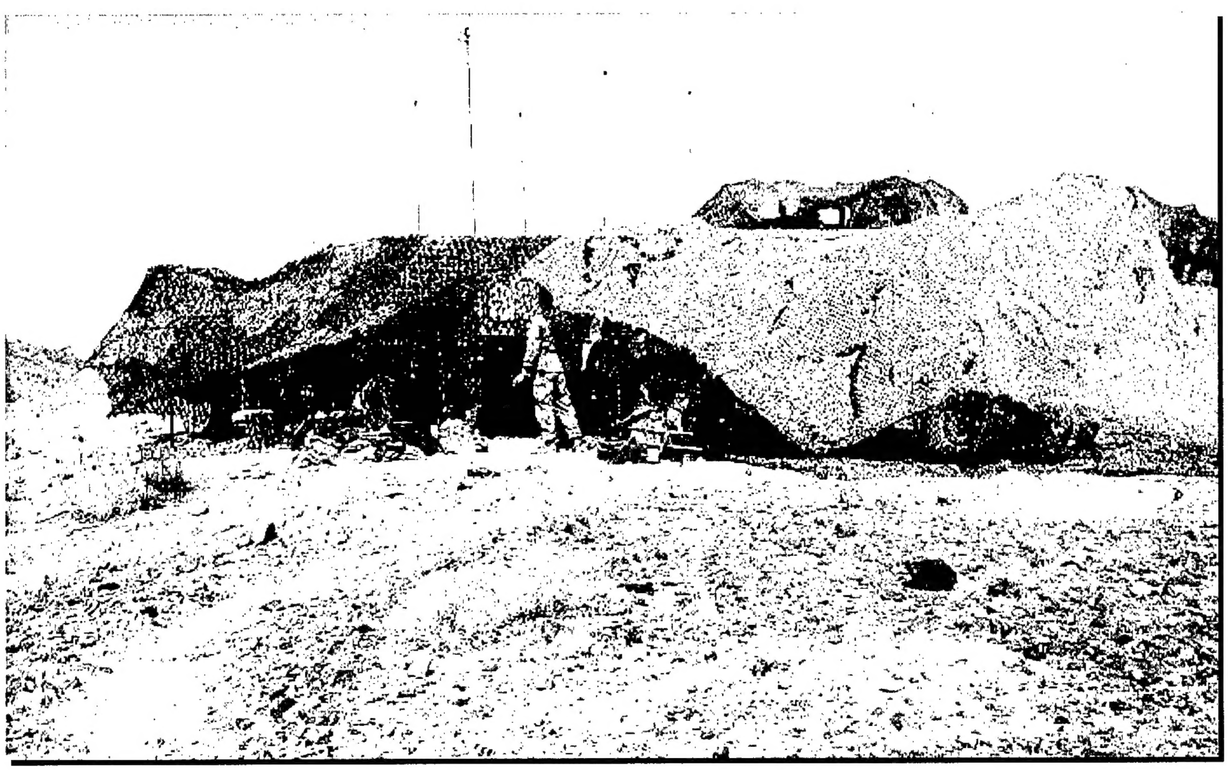

Figure 1. Regimental Combat Operations Center, Marine Corps Air–Ground Combat Center, Twentynine Palms, California.

Paradoxically, however, the degree to which information is uncertain is not typically presented to tactical decision-makers. Instead, the battle staff planning process digests the available information—certain and uncertain alike—and presents one or more courses of action to the decision-maker reflecting an interpretation of that information. In effect, uncertainty is purposefully scrubbed from the picture for simplicity and clarity, and data and inferences are treated as certain. Lipshitz and Strauss (1996, 1997) identify this "suppression of uncertainty" as one of five strategies for coping with uncertainty. The literature suggests that people tend to shift approaches dynamically in the course of decision-making based on the information that they confront* (Payne, Bettman, Coupey, and Johnson, 1992; Payne, Bettman, and Johnson, 1993).

In the following two experiments, we investigated two questions:

1. Can situation awareness and tactical decision-making be improved by displaying information about uncertainty in ways that are easier to understand and use?
2. How does uncertainty affect tactical decision-making and how can its adverse effects be minimized or eliminated?

In Experiment I, we investigated whether graphical representations of enemy intent enhanced memory and situation awareness for that information above baseline. In Experiment II, we investigated whether the level of uncertainty regarding enemy strength and capabilities would influence the time it takes to make a tactical decision and the nature of the decision itself.

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* G. Klein, J. Schmitt, M. McCloskey, J. Heaton, and S. Wolf. 1996. "Fighting the Fog: A Study of Uncertainty in the U.S. Marine Corps." Contract Summary Report under USC P.O. #681584. Klein Associates, Inc., Fairborn, OH.

EXPERIMENT I
DISPLAYING UNCERTAIN ENEMY INTENT

The literature on decision-making is replete with taxonomies of uncertainty*, so the first task was to determine which types of uncertainty are most important to situation awareness and which are worthy of additional investigation. Based on an Uncertainty Workshop hosted by Space and Naval Warfare Systems Command and discussions with Marines and other subject matter experts, it has become increasingly clear that *enemy intent* is a key factor to tactical-decision making that is inherently uncertain. Consequently, clearly depicting the degree of uncertainty with respect to (inferred) enemy intent and capabilities should significantly improve situation awareness and tactical decision-making. While it is obviously not possible to eliminate uncertainty, our intention was to investigate means of displaying uncertain information (in particular, enemy intent and capabilities) to improve decision-making.

Although enemy intent and the movement of enemy forces are crucial in tactical planning, these factors are not directly observable and must be inferred from other (observable) information. Relevant information for tactical planning includes terrain, infrastructure (including roads, bridges, and fortifications), targeting information, current unit dispositions, and friendly and enemy movement capabilities. Determining future positions, therefore, involves significant encoding of information and inferential computation.

Commanding officers, however, have neither adequate time nor unoccupied mental resources to perform these tasks for themselves. Instead, their staffs provide periodic "SitReps" (situation reports) and planning briefings. Commanding officers can also examine the many maps, graphs, and other information positioned throughout the command post to display different types of situation information. However, the current method of displaying the tactical situation has many drawbacks, including:

1. The need for periodic briefings that necessarily summarize details to present a simple and clear picture,
2. The incomplete and piecemeal nature of the current information displays, and
3. The requirement that the commanding officer synthesize the information from the many maps and other sources and remember information between briefings.

These drawbacks result from information on the maps (and other information sources) that is scattered, almost certainly out of date, and that generally does not display important inferences.

If enemy intent (with its accompanying uncertainty) could be displayed graphically, it might be possible to improve the decision-maker's situation awareness and tactical decisions. Our initial approach was to display likely future positions of enemy units on a situation map. This approach reduces the computational demands on the decision-maker because the inference is already determined. Decision-makers may mentally check or recompute this inference, but we argue that recomputing the inference is likely easier than computing it from the start. Second, mental storage

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*Ibid.

and cognitive processing efforts are reduced because the display is external to the decision-maker and available at the cost of a look. Third, the graphical representation of enemy intent may improve situation awareness by helping the decision-maker to visualize and integrate the battle situation into a coherent story that is easier to understand, remember, and think about.

Unfortunately, situation awareness and improved decision-making are difficult to operationalize and measure. Our solution was to measure situation awareness by asking experiment participants to study a map of a battle situation and then recall current enemy positions and anticipated future positions. If the graphical representation of enemy intent improves situation awareness, then current and future enemy positions should be more readily recalled.

Our hypothesis is that a good graphical representation leads to better recall of enemy intent and future position than either textual or implicit representation of that information on a battlefield map. Better recall implies better situation awareness, which should lead, in turn, to enhanced decision-making performance.

Participants were U.S. Marines with varied backgrounds in battalion and regimental Combat Operations Centers (COCs). Each participant saw a practice tactical situation followed by a (single) test tactical situation. There were four conditions or methods of displaying enemy intent together with its corresponding uncertainty: a *baseline* condition in which enemy intent and future position information must be inferred from the situation (which, essentially, corresponds to current practice), a *textual* representation, and two different *graphical* representations of enemy intent and future position.

METHOD

Participants

The participants were 28 Marine Corps officers and senior staff noncommissioned officers with varying experience in reading and using standard military topographic maps.

Materials

We created two different vignettes, each illustrating a different battle situation. Vignette "A," depicting an offensive situation, consisted of eight friendly and five enemy units. Two of the enemy units were associated with one text box that contained information about unit identification, intent, source of information, and time of the last information update. The other three enemy units were associated with a similar text box. One box indicated that the associated units were confirmed for identification and location. The other box indicated that the associated units were unconfirmed for identification and location.

Vignette "B" depicted a defensive position consisting of 9 friendly and 14 enemy units. Two enemy units were associated with one text box and one enemy unit was associated with a second text box. Again, one box described units that were confirmed for identification and location, and the other box described unconfirmed units (figure 2).

Unit Identification: Confirmed

Parent Unit ID: Confirmed

Location: Confirmed

Battle Intent: Support the main attack with elements of two Bn Task Forces; armor/mechanized force; anti-armor weapons; artillery support

Source: imagery, Humint

Last Update: 200245 Z Jul

Unit Identification: Unconfirmed

Parent Unit ID: Suspected/determined (70)

Location: Suspected (50)

Battle Intent: Suspected; enemy may 1) support the main attack with elements of Bn Task Force or 2) reinforce the holding action with elements of one Bn Task Force; mechanized force; anti-armor weapons; artillery support

Source: Imagery, Elint, Comint

Last Update: 192235 Z Jul

Figure 2. Examples of confirmed and unconfirmed text boxes.

Future enemy positions were represented in one of four ways, resulting in the four stimulus conditions of this experiment. For the *baseline* condition, future positions were not represented by any means; subjects were required to infer future enemy positions from other information on the map. For the *textual* condition, future positions were represented by text descriptions located at the bottom of the text boxes. Each unit was designated by its map coordinates, and the major axis (or axes) of advance was (were) indicated by compass direction and distance. For example, a description might be "Position–6 hrs: Armor Company (0072) 2K SSE or 1K E" (which translates as "The position in 6 hours time of the armored company located in grid square 0072 will be 2 kilometers south–southeast or 1 kilometer east"). The intent and future positions considered roads, geography, and the battle situation.

For the first of the two *graphical* conditions—"arrows"—we drew dotted arrows to indicate the most likely movement of enemy units. The points of the arrows indicated the positions where the units would be in 6 hours, and 2- and 4-hour limits of advance were depicted as notches on the arrow shafts. For the other graphical condition—"blobs"—we drew boundaries around enemy units to convey the message that the unit might be anywhere within the boundary in 6 hours' time. The shape of the boundary conveyed the intent and general course of unit movement (See figures 3 and 4).

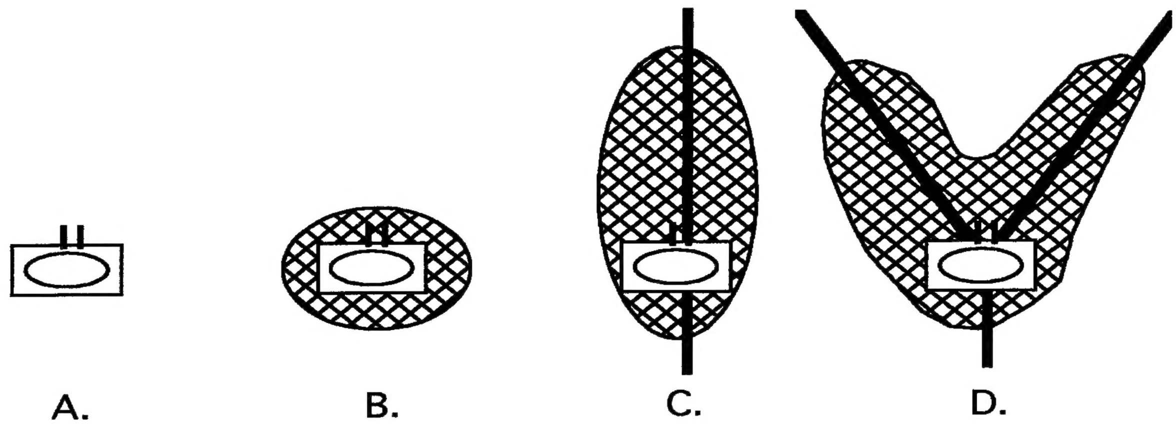


Figure 3. Four examples of future position blobs: (A) stationary, (B) stationary with some jitter, (C) moving up a road, and (D) branching on either of two roads.

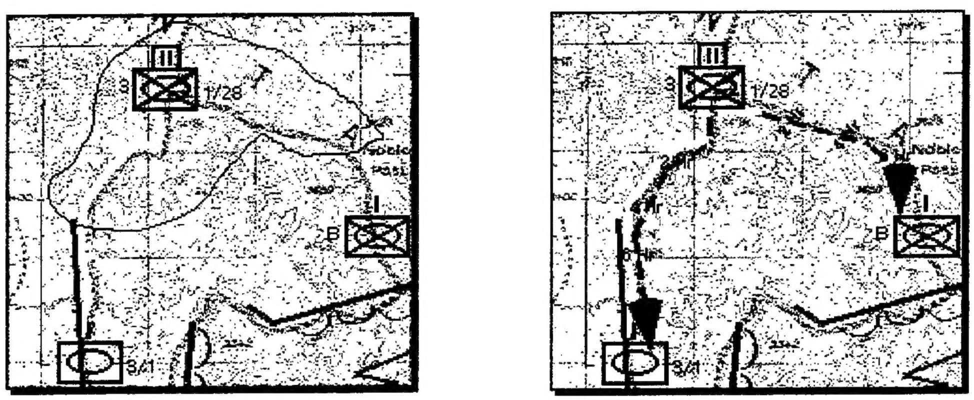


Figure 4. Blob and arrow representations. Blob representation for one unit (left). Arrow representation for the same unit (right).

Procedure

Participants were informed about the nature of the situation maps that they were going to see and what they were expected to recall. They were also advised that thinking about the battle situation would likely improve their performance. The nature and purpose of future position information were also explained for the text and graphic conditions. Each participant then saw vignette "A" followed by vignette "B."

For each of the two vignettes, participants were given 5 minutes to study a situation map. This map was then removed and replaced by a similar map, but with all enemy units and fortifications removed. Participants were first asked to recall the position, type, and size of each enemy unit by drawing these units on their maps. When they were satisfied with their recall, they were asked to draw the anticipated positions of each enemy unit 6 hours into the future. For the *baseline* condition in which this information was not presented, participants were required to make inferences from available (contextual) information. For the *text* and *graphic* conditions, participants only had to recall the future position information that was provided on the study map.

After completing the map recall, participants answered a short series of additional questions about information that was presented in the text boxes: the location of the unconfirmed units, the sources of information, the suspected battle intentions, and the age of the last update. Participants were also asked how confident they were of their recall and their answers to these questions.

RESULTS

Vignette "A" was treated as a practice trial, and only vignette "B" was scored or analyzed. The type, size, and position of each recalled enemy unit were scored for correctness. Unit type and size were scored by counting the number of units correctly recalled. Position was scored by counting the number of units that were recalled within the correct (1 km x 1 km) grid square, within one grid of the correct grid square, and within two grids of the correct grid square.

Three representative enemy units were selected to score for accuracy of relative direction of movement, relative distance of movement, and absolute future position. For relative direction, errors were scored as being (1) ±15 degrees of the correct relative direction from the unit, (2) ±30 degrees, or (3) worse. For relative distance, errors were measured as the number of kilometers between the correct distance that the enemy units would move and the recalled distance. For absolute position, errors were measured as the number of kilometers between the correct final position and the recalled final position. For units with more than one potential future position, each position was scored and combined into a total for that unit. Figure 5 shows the future position scores.

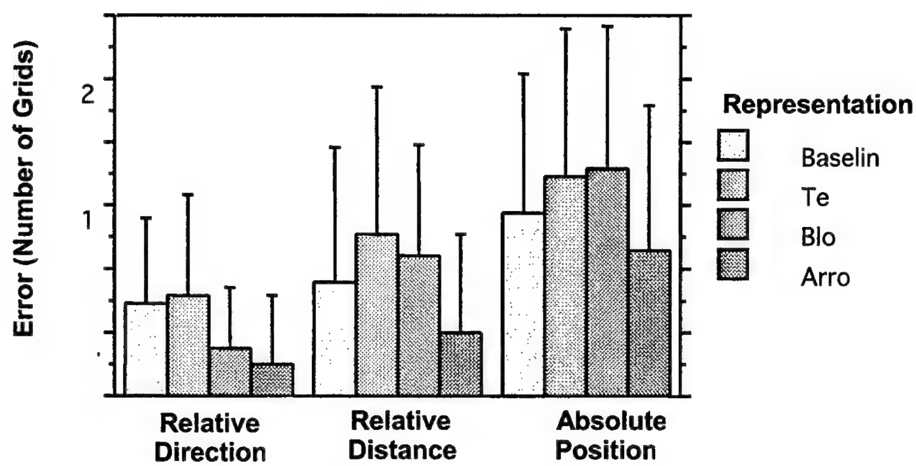


Figure 5. Recall of enemy unit future position information.

The scores were submitted to analyses of variance. For the recall of unit types, sizes, and current positions, no significant differences were found among the four conditions. Before leaving this point, it is worth reflecting on this issue and agreeing that current enemy status—including the type, size, and location of enemy units—is unquestionably critical information. In today's COC, enemy (as well as friendly) units are often displayed as pushpins or Post-It® notes attached to the map. These can, and frequently do, disengage themselves from the map and fall to the ground. When this occurs, perhaps someone will notice, perhaps not. If the pushpin or Post-It® note is discovered, perhaps it will be returned to the correct position on the map, perhaps not. Clearly, a significant improvement

in geo-referenced unit representation is one that maintains accurate (and up-to-date) locations for all enemy and friendly units.

For the recall of future positions, a significant difference was found pertaining to relative direction ($F(3,68) = 3.29, p = .03$) and a marginally significant difference for relative distance ($F(3,68) = 2.14$, $p = .10$). Analysis of variance revealed no significant differences concerning ability to determine absolute position.

Fisher's least-significant difference post-hoc tests were conducted to identify the specific (statistically significant) pairwise differences among the experimental conditions. Participants determined relative direction marginally better in the blobs condition than in the baseline condition ($p = .09$). Participants performed better with the arrows than with text ($p = .01$), better with arrows than in the baseline condition ($p = .02$), and better with the blobs than with text ($p = .05$). For relative distance, subjects performed better in the arrow condition than in the text condition ($p = .02$).

Parenthetically, although Fisher's least-significant difference post-hoc test is not the most conservative test that we could have used to examine the pairwise differences among arrows, blobs, and text representations, it allows us to explore all possible combinations with less-stringent rejection criteria, as we intended. The present study represents a preliminary, exploratory study of uncertainty in the field and it is therefore necessary that we consider all potential areas of difference. Before identifying the most suitable uncertainty representations, additional research will be necessary under additional tactical conditions, using other applied shaping factors and variables.

DISCUSSION

To summarize, the blobs and arrows improved recall of the relative direction of enemy future positions and the arrows also improved recall of the relative distance of enemy future positions. However, no representation improved recall of absolute future positions of enemy units. Therefore, if the current position of a unit were recalled incorrectly, the future position of that unit would be in a similar degree of error (although its *relative* future position would properly show its incorrectly recalled current position). We conclude that both the blob and arrow graphical representations of enemy intent are helpful for recalling this important tactical information. This result coincides with research (e.g., Kirschenbaum and Arruda, 1994) that suggests that graphic representations are best when displaying spatial information.

At the conclusion of the experiment, we interviewed many Marine officers and staff noncommissioned officers and asked for their preferences and observations, particularly regarding the blobs and arrows. Many suggested that a combination of both blobs and arrows would be useful. They indicated that the blobs effectively conveyed *potential* enemy movements while the arrows effectively conveyed *most likely* enemy movements and their timing. We plan to pursue this suggestion with usability studies.

EXPERIMENT II
EFFECTS OF SITUATIONAL UNCERTAINTY ON DECISION-MAKING

Military decision-making takes place under uncertain, time-constrained conditions, and in a tactical environment, groups frequently opt for riskier choices than individuals[†]. However, the effect of "situation uncertainty" (i.e., uncertainty of information regarding critical factors such as enemy location, intent, and composition) on the timeliness and content of a commander's decisions is not well-understood. Consequently, the purpose of this experiment was to examine the effect of situation uncertainty on decision time and choice of battle plan in a series of three controlled tactical scenarios.

One-hundred-twenty Marine Corps officers and staff noncommissioned officers with varying amounts of command post experience engaged in a series of three tactical decision games (TDGs). The level of uncertainty concerning enemy troop size and composition varied between games. During the course of each TDG, the participants' task was to choose one battle plan from among three options. Game reading and decision times were recorded. The purpose of this investigation was to determine whether

1. Increasing situation uncertainty would lead to more choosing to "wait-and-see" (presumably to gather more information about the enemy before choosing a plan of action),
2. Increasing situation uncertainty would lead to slower decision-making, and/or
3. The effects of situation uncertainty would differ for more- and less-experienced decision-makers.

METHOD

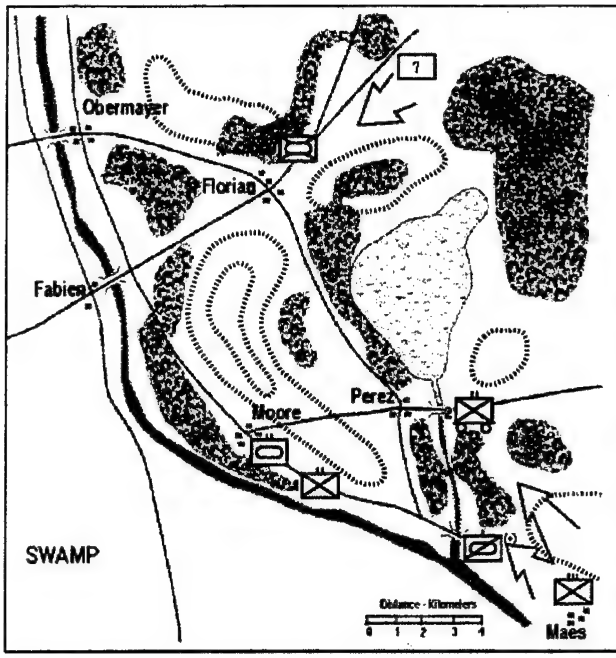
Participants

The participants in this experiment were students at three formal schools at the Marine Corps University in Quantico, Virginia. The participants included 1 Lieutenant Colonel and 11 Majors from the Command and Staff College, 75 Captains and 2 Lieutenants from the Amphibious Warfare School, and 26 Gunnery Sergeants and 5 Staff Sergeants from the Staff Noncommissioned Officer Academy. The combat operations center experience of the officers ranged from none to 11 years. The combat operations center experience of the staff noncommissioned officers ranged from none to 1.5 years. For both officers and staff noncommissioned officers, experience with TDGs varied from none to 2 years of experience as a TDG instructor.

[†] J. Leddo, M. O'Connor, J. Doherty, and T. Bresnick. 1996. "Decision Making under Uncertainty and Time Stress. Contract Summary Report, MDA903-89-C-0031. Decision Science Consortium, Inc., 1895 Preston White Drive, Suite 300, Reston, VA 222091.

Materials

The experiment involved three TDGs. The games were modified from games published in the *Marine Corps Gazette* and *Mastering Tactics: A Tactical Decision Game Workbook* (Schmitt, 1994). Each game consisted of a color map of a tactical situation, an approximately 200-word description of the situation, and a set of three response options. The map and description were presented on one 8-1/2" by 11" sheet of paper; the options were presented on a separate sheet (figure 6).



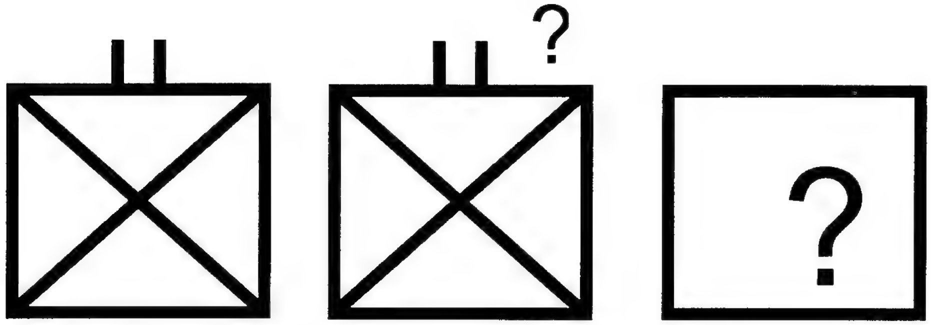
You are the commander of the 4th Marines, which consists of two battalions on trucks, one battalion of assault amphibious vehicles (AAVs), a tank battalion, and a reinforced light armored infantry (LAI) company. An enemy regiment battered your 1st Battalion 24 hours ago in an engagement east of Maes. Following that action, 1st Battalion withdrew west across the creek. You now hold the bridges across the creek with 2d Battalion and the LAI company. The tank battalion is in reserve near Moore. Your 3d Battalion protects the northern flank near Florian, while the first enemy regiment is to the east of Maes. Your mission is to hold a bridgehead until reinforcements can arrive from thewest in about 72 hours.

Your S2 reports that enemy infantry elements have been sighted approaching Florian from the northeast. He does not know how many units or their composition. 3rd Battalion's elements are beginning to fall back under pressure. An enemy unit, which consists of infantry reinforced with a limited number of tanks, is advancing generally from the east. The enemy regiment to the south is apparently consolidating and preparing to occupy Maes. What is your plan of action while you await reinforcements?

Figure 6. One of the three TDGs used in the Experiment II. A second page (not shown) presented three plan options. The enemy unit shown moving from the upper right is of unknown size and composition ("?").

For each of the three games, we created three levels of uncertainty concerning the size and composition of the enemy unit. In the Low Uncertainty condition, the size and composition of the unit were known. In the Medium Uncertainty condition, the size of the unit was described as possibly one size, but probably larger (e.g., a unit might be described as possibly a battalion, but probably a regiment). In the High Uncertainty condition, the size and composition of the unit were unknown. The levels of certainty were indicated graphically on the map and described in the text. Figure 7 shows the graphical symbols.

The response options for each game were designed to fit different interpretations of the battle situation caused by different assumed sizes of the uncertain enemy unit. One option described a plausible response if the uncertain unit were assumed the smaller of its two plausible sizes. The second option described a plausible response if the unit were assumed the larger of its two plausible sizes. These response options were, in effect, decisions to act immediately. The third option described a plausible response to wait for additional intelligence about the enemy unit's size. We carefully made all three options as sensible and plausible as possible. For each game, the responses were listed in a different order.



Low Uncertainty (Full Information) | **Medium Uncertainty** (Best Guess) | **High Uncertainty** (Unknown)

Figure 7. Levels of uncertainty symbols.

Procedure

The participants were run in groups of 3 to 10, though all worked individually with their own materials. The TDG order of presentation was fixed. Each participant experienced all three levels of uncertainty. Level of uncertainty was counterbalanced across TDGs and order of presentation using a Latin Square design. The participants proceeded at their own pace through the TDGs.

For each TDG, participants were given a blank response sheet. Participants were asked to time themselves to the second as they (1) started reading the text of a TDG, (2) finished reading the text and started reading the response options, and (3) decided on an option. To obtain accurate reading versus decision times, participants were encouraged to read the text once and write down the time before reading the options and considering their responses in any depth. Clearly, this procedure can only be moderately precise, so we must view reading versus decision times with reserve.

RESULTS

First, for all three TDGs, all three tactical decision options were chosen frequently. This result confirms that our stimuli were realistic and the options were reasonable. Second, the "wait-and-see" option was chosen roughly one-third of the time, overall. This result means that waiting was an acceptable and common choice despite frequently articulated doctrine (such as General George Patton's aphorism that "a good plan violently executed *now* is better than a perfect plan next week") to the contrary.

Next, we split the participants into two groups according to level of tactical decision experience to examine whether decision choice varied with experience. We measured tactical decision experience in three different ways: rank, years of service, and days of command post experience. Interestingly, years of service and days of command post experience did not correlate, $r(118) = .117, p = .21$. Even among the captains only, whose experiences one might expect to be similar, the correlation only reached $r(75) = .142, p = .22$. Among the officers only, whose experiences one also might expect to be similar, the correlation only reached $r(87) = .178, p = .10$. (One officer was removed because his experience report appeared to be unrealistically excessive.) Most importantly, it was the amount of command post experience alone that differentiated among tactical decision choices.

Experimental participants reflected a diversity of COC experience: 38 participants had no command post experience at all, while 32 had more than a year of command post experience. The median was 14 days in a command post. We split the participants into more- and less-experienced groups at the median and used the nonparametric Cochran Q statistic to test waiting versus acting at each of the three levels of uncertainty (figure 8). For the less-experienced participants, more situation uncertainty led to more participants choosing the "wait-and-see" option, $Q(2) = 10.15, p < .01$. However, for the more-experienced participants, increasing situation uncertainty had no effect on option choice, $Q(2) = .76, p > .6$. Interestingly, we found no differences for response times for either the more- or less-experienced participants (figure 9).

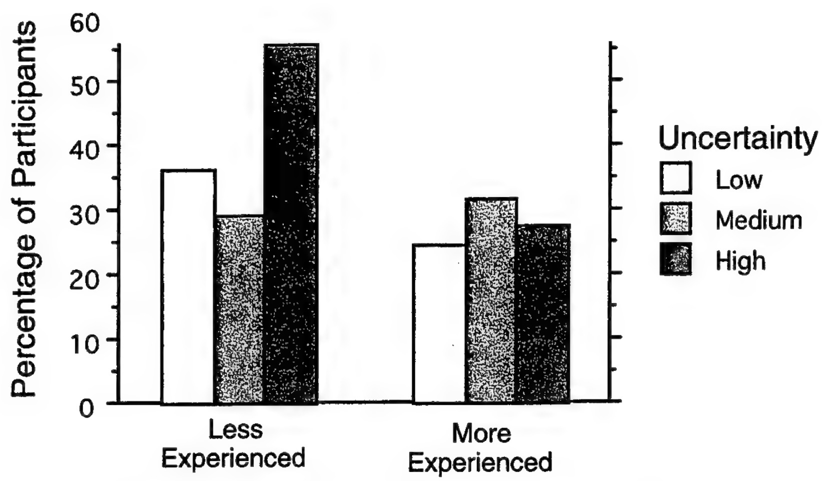


Figure 8. TDG choices for more- and less-experienced participants.

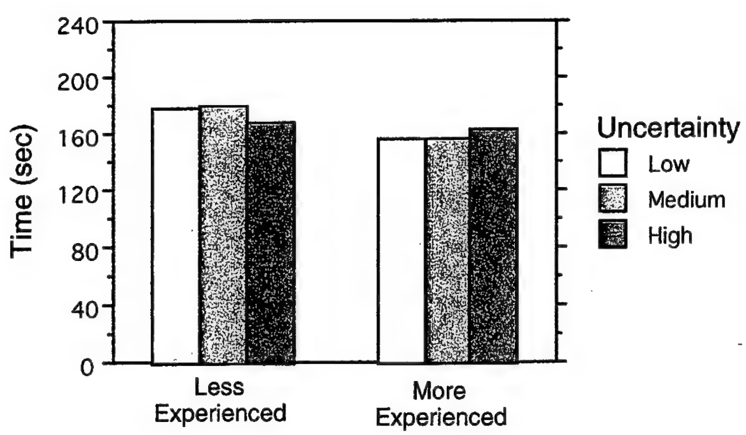


Figure 9. Time to decide on a plan option. Time is measured from ending of reading the scenario to deciding on an option.

It could be argued that grouping commissioned and noncommissioned officers together results in excessive variation caused by putative differences in education, experience, training, and so forth. To address this objection, we examined the officers separately. For officers, the median COC experience

was 45 days. Again, there was no compelling correlation between years of service and COC experience, although the small correlation we found approached statistical significance ($r(87) = .178$, $p = .10$). As before, a Cochran Q statistic found that less-experienced officers more frequently chose the "wait-and-see" option in the more uncertain scenarios ($Q(2) = 6.6$, $p < .05$) while their more experienced counterparts did not choose differently in the more uncertain scenarios ($Q(2) = 1.0$, *ns*).

DISCUSSION

Participants with less COC experience increasingly chose the "wait-and-see" option as situation uncertainty increased. However, participants with more COC experience were not influenced by increasing situation uncertainty.

Increasing situation uncertainty did not influence participants' reading and decision times. This finding may reflect certain well-known cognitive and decision-making biases, such as reliance on the first-derived solution[*‡] and the over-reliance on past experience and the minimization of negative and conflicting evidence (Reece and Matthews, 1993). In addition, the finding that days of COC experience predicted choice while years of service and rank did not predict choice is intriguing. Similarly, the small and statistically non-significant correlations between COC experience and years of service and rank are also interesting. What these data suggest is that years of service (and, presumably, exposure to doctrine) alone do not affect tactical decision choice in the way that time spent in a COC does.

Study results identify several viable avenues for future research. One such line of research involves the investigation of training strategies to improve less-experienced Marines' decision-making. For example, is it possible to increase COC experience through simulation, the use of additional TDGs, or other training and conditioning to act rather than wait for the scenario to develop? Another avenue to pursue involves investigating why there were no apparent differences in the time required to reach a tactical decision—among participants with differing degrees of experience and scenarios involving differing levels of uncertainty. Building a dynamic scenario in which the Commanding Officer has access to more than "summary" information (e.g., details of the S2's supporting evidence) may provide a more realistic setting in which to examine the timing and choice involved with tactical decision-making.

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[*] Klein et al., *op. cit.*

[‡] G. Klein, J. Schmitt, M. McCloskey, J. Heaton, D. Klinger, and S. Wolf. 1996. "A Decision-Centered Study of the Regimental Command Post." Final Contract Summary Report under USC P.O. #681584. Klein Associates, Inc., Fairborn, OH.

GENERAL DISCUSSION

Uncertainty is an inevitable component of military and naval operations. Previous research[‡] has documented the pervasiveness of uncertainty as a key barrier to effective decision-making and has pointed to the influence of uncertainty across the entire spectrum of decision-making activities.

Our intent in these experiments was to investigate the extent to which graphical representations influence situation awareness and uncertainty and, therefore, decision-making. These experiments address issues of uncertainty in a battlefield context—in particular, techniques for displaying uncertain information and the effect uncertain information has on decision-making.

In Experiment I, "blobs" and "arrows" tended to boost participants' ability to recall uncertain information about enemy intent. Graphical depictions combining "blobs" and "arrows" may contribute most to recall. In Experiment II, we learned that participants with the least COC experience were most influenced by the degree of information uncertainty in a tactical decision game. When enemy information was most uncertain, less-experienced participants were more likely to choose a "wait-and-see" response. This finding suggests that, contrary to expectation, it is neither rank, military occupational specialty, nor time in service that predicts the response of a Marine officer or staff noncommissioned officer in a tactical decision-making scenario. Instead, simply spending time working in the COC environment seems critical to the development of decisive decision-makers (figure 10).

Further study of these issues will help us design better displays for information presentation and identify important training issues for the execution of effective command and control.

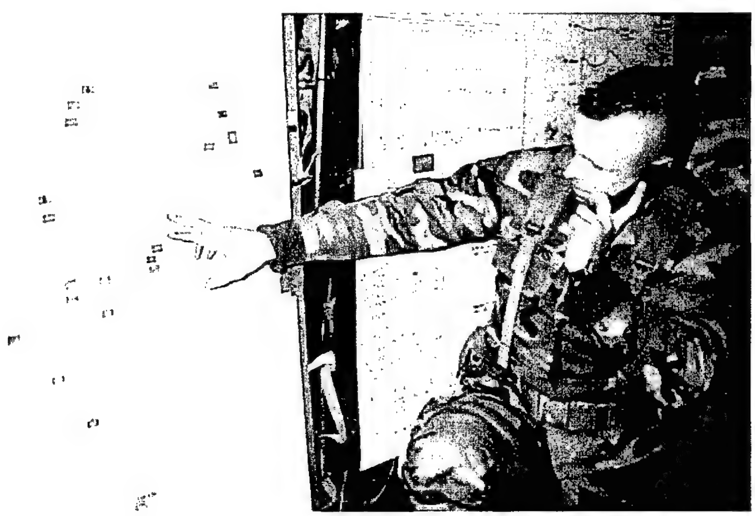

Figure 10. Regimental S-2 (Intelligence Officer) verifying locations of enemy units.

[‡] Ibid.

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14. ABSTRACT
This report discusses the results of two experiments conducted on the effect of uncertainty situation awareness and tactical decision-making. In Experiment I, testers investigated whether graphical representations of enemy intent enhanced memory and situation awareness for that information above baseline. In Experiment II, they investigated whether the level of uncertainty regarding enemy strength and capabilities would influence the time it takes to make a tactical decision and the nature of the decision itself.

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